



Design, Modeling, and Development of Precision Apertures

Gregory Washington

Intelligent Structures and Systems Laboratory
Ohio State University
Columbus, Ohio 43210-1107





Characteristics of Smart Antennas

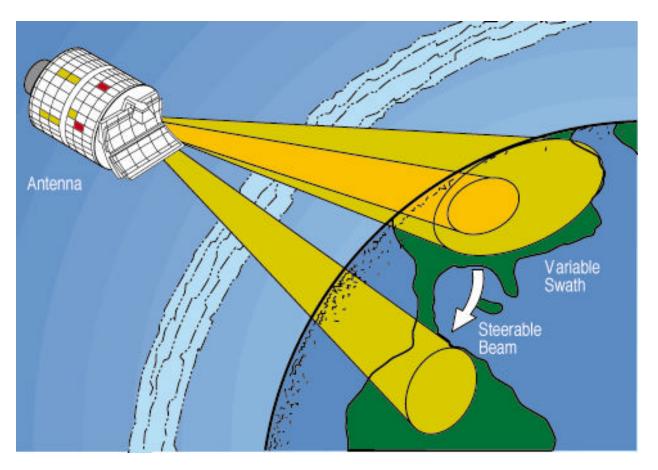


- 1. Two functions achieved by changing the reflector shape
 - (1) Beam Steering -- first mode
 - (2) Beam Shaping -- second mode
- 2. Advantages of using smart antennas
 - (1) Transmitted power maximization under the atmospheric disturbance or thermal distortion of the reflector
 - (2) Ability to vary the coverage area
 - (3) User defined radiation pattern





Mechanically Active Antennas









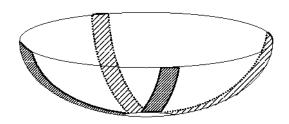
Modeling issues

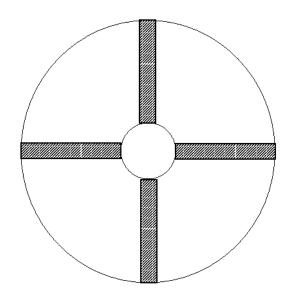
- 1. Quasi static shape control
- 2. Boundary Value Problems(8 undetermined coefficients)
- 3. The actuation forces need to be expressed analytically and applied as boundary conditions





Doubly Curved Aperture Antenna





- Outer radius : 0.3 (m)
- Inner radius : 0.01 (m)
- Radius of curvature : 1 (m)
- Material of the reflector:

Metalized LEXAN of

(m) thickness

• Actuators : Four Thunder PZT

Actuators

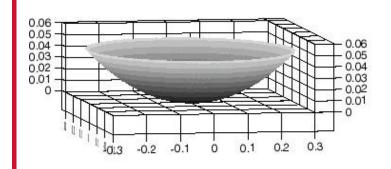
• Frequency of Signal: 11.8 GHz

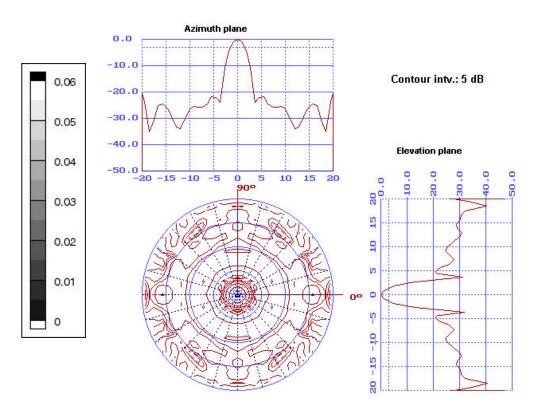






Results (Undeflected shape)



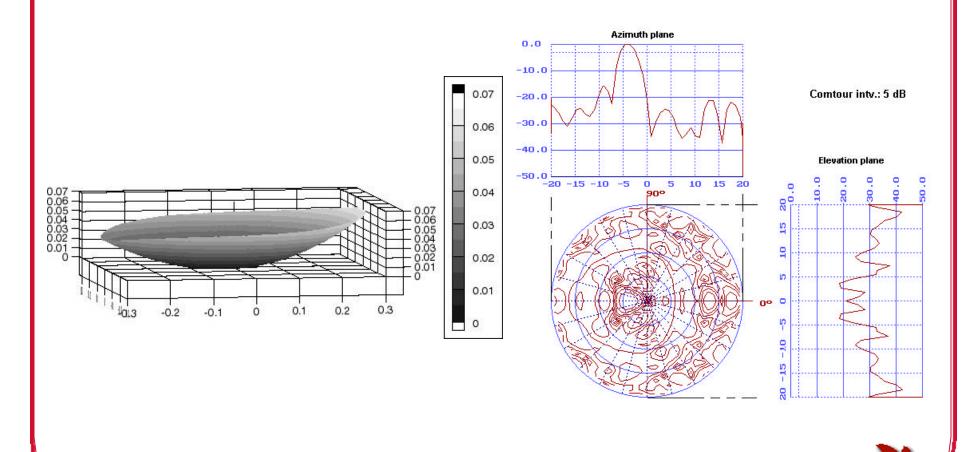








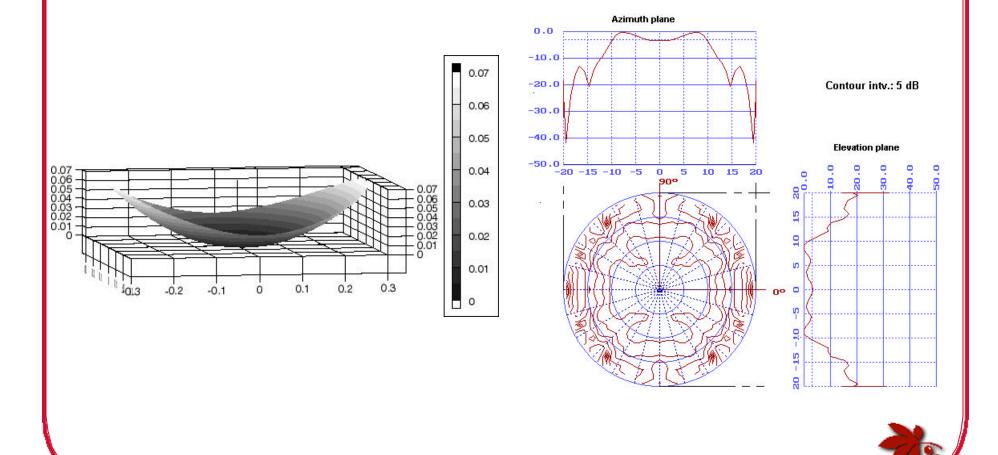
Results (1st Mode)







Results (2nd Mode)





Construction of Doubly Curved Smart Antenna





Mold for forming a small scale doubly curved reflector



Thunder actuators





Actual Model of Doubly Curved Smart Antenna





Front surface



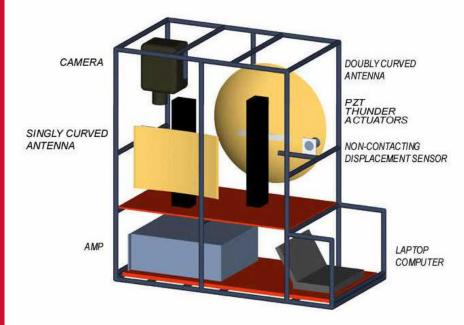
Back surface





Zero-G Testing of Aperture Antennas





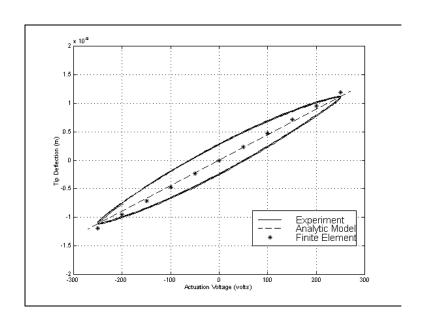


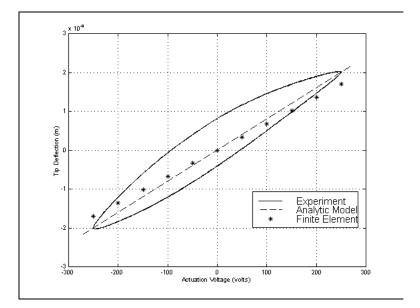
• Testing aboard NASA's KC135-09 Aircraft





Zero-G Testing of Aperture Antennas (Con't)









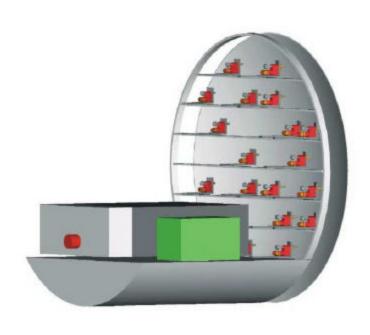
Point Actuated Precision Apertures

- 1. Useful life time of geostationary communication satellites is getting longer
- 2. Satellite antennas designed to cover one area are being used to cover different areas during its life time.
- 3. It is required that satellite antennas have ability to change their radiation pattern
- 4. Advanced Communications especially space based technology represents an enabling technology for future military applications
- 5. Potential spin-offs: Include Low cost MRI units, Large Telescopes. Missile Defense

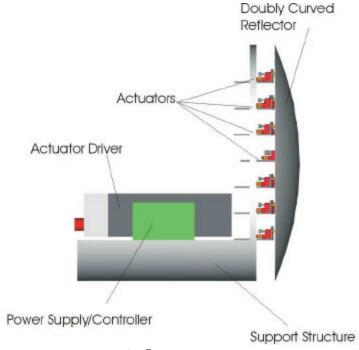




Smart (Point Actuated) Contour Beam Antenna



Perspective View



Side View

•Utilizes up to 40 Picomotor point actuators to actuate an antenna surface

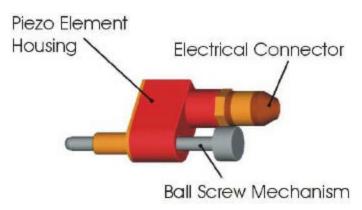


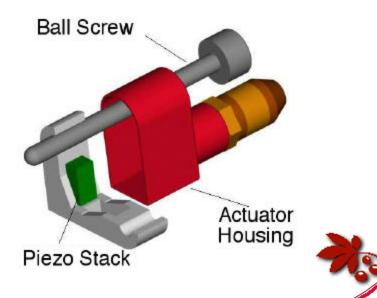


Point Actuation



- •Actuation stroke = 0.5 mm/min
- •Actuation force = 10 Newtons
- •The piezoelement is a stack actuator in D33 mode
- •Piezoelement Stick-Slip mechanism









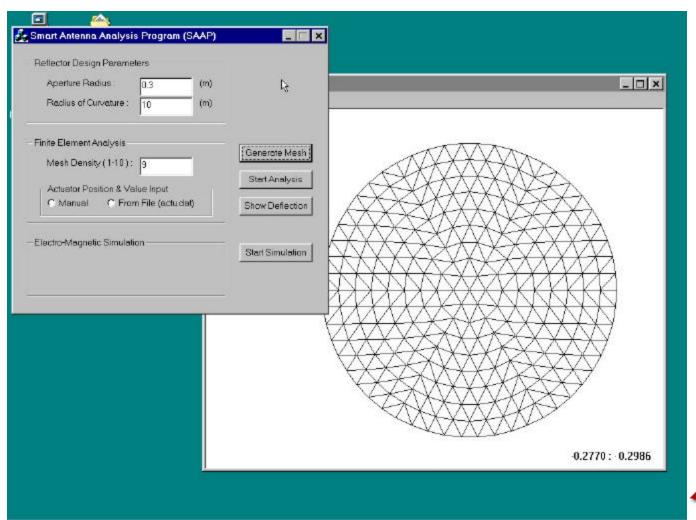
Contour Beam Antenna Adjustment Algorithm

- Assume initial shape
- •U.V. Space template
- •Calculate Far Field pattern
- •Form Cost Function
- •Take Cost function derivatives (in terms of actuator amplitudes
- •Adjust Actuators via steepest decent and Genetic Algorithm
- •Form new surface





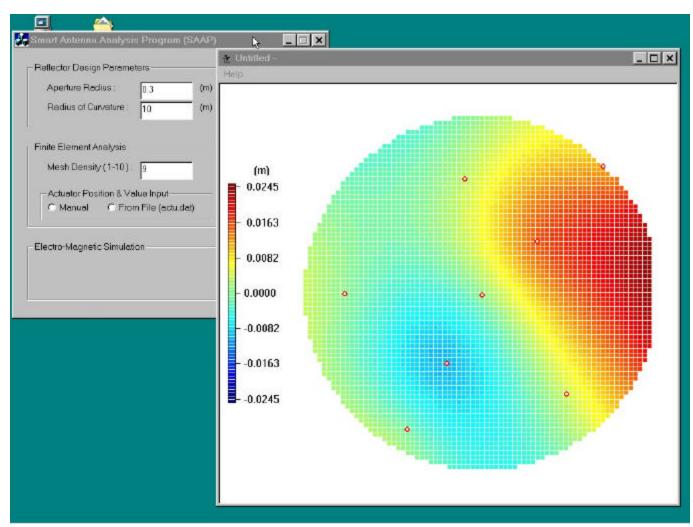
Smart Antenna Analysis Program







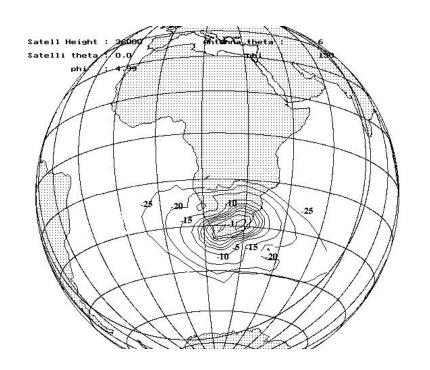
SAAP (Continued)

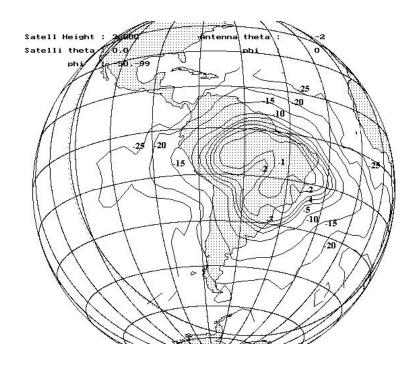




Antenna Data (Brazil/SouthAfrica)





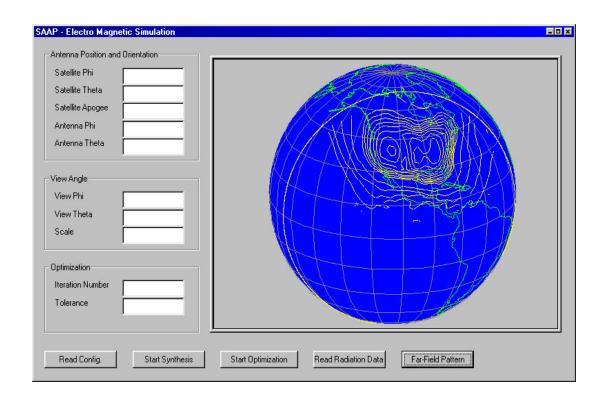


• Same Antenna being used to send a signal to Brazil or South Africa





SAAP- Electromagnetic Info

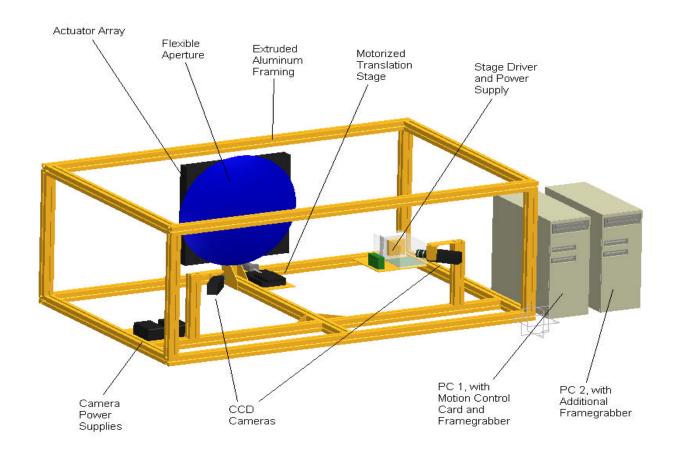


•FEM and EM codes are included in one program to calculate the far field radiation Pattern





Surface Validation Mechanism







Accomplishments

Task	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Advanced Surface Modeling					112							
Analytical Development	800 E01	1000	OCCUPANT OF THE PARTY OF									
Finite Element Code Generation				-70 10	Vanish is							
Surface Validation					III COST							
Experimental Validation						100000		in the				
Reflector Shell Fabrication					24 A							2
Actuator Development	-3(0)	3000										
Actuator Modeling/Control		-	1	With the same								
Materials Search		STATE OF	[100020]									
Mold Design/Fabrication				THE CO.								
Reflector Shell Construction												
Control System Development												
Reflector Surface Measurement							11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					
Control System Design				Western	Ø22490	0	10000	-				
C-Code generation						0-1-1-1	-	2 0000	W. W.			
Microprocessor Implementation							= 000		DO TOUR			
System Integration												
Antenna Housing Design		00000	2000000									
Antenna Housing Construction			Contract of	STATE OF THE STATE OF	501 33							
Component Assembly								5 00 0	The said			
Power Electronics Issues					100000	100000000	PROFE					
System test and Debug										Same		
Radiation Pattern Testing												
Electromagnetic Field Code Development												
Feed Horn Design					Name of	No. of Lot	THE PARTY NAMED IN	To the last of				
Compact Range Testing**									1000			
Information Dissemination												
Year 1 Report				-								
Year 2 Report												
Year 3 Report								-				0000

• Al first year task on Gantt chart have been completed (Except Antenna Housi)







Major Milestones

- •Singly and Doubly Curved Aperture Antennas have been analytically modeled and tested (December 1999)
- •A doubly curved piezoelectrically actuated reflector structure was built and tested. (December 1999)
- •Zero Gravity testing was concluded (March 1999)
- •Point Actuated Antenna Simulation has been Completed (May 2000)
- •Field Testing will conclude in late Summer 2000
- •Building of Antenna Construction Facility (Summer 2000)
- •Surface Validation Experiment (Summer 2000)
- •Initial Point Actuated prototype (December 2000)
- •Surface Actuation Optimization completion (June 2001)







Potential Issues

- Access to proper surface materials
- Actuator Hysteresis
- Power Demand Issues
- Actuator Noise
- Partnering issues

